Ashley National Forest Assessment

Energy Resources, Mineral Resources, and Geological Resources and Hazards Report

Public Draft

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for:
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Introduction

As part of our forest planning process, the 2012 National Forest Planning Rule requires us to assess available information about renewable and nonrenewable energy resources, mineral resources, and geologic hazards. This report provides an assessment of those resources within the Ashley National Forest. Although not required by the planning rule, this assessment also evaluates abandoned mines and geologic resources because they are also important.

Types of Energy and Mineral Resources

The Ashley National Forest contains a wide variety of energy and mineral resources, and people have been using and benefitting from those resources for many years. Energy resources are typically classified as either renewable or nonrenewable. Renewable energy sources evaluated in this assessment include solar power, hydropower, wind energy, biomass, and geothermal energy. Nonrenewable energy sources evaluated include crude oil, natural gas, coal, tar sand, and oil shale, all of which are managed on federal lands as leasable minerals.

Mineral resources on federal lands are classified into three different categories: locatable minerals, leasable minerals, and salable minerals, because different laws and regulations apply to the exploration and development for minerals in each category. All three categories of mineral resources will be evaluated in this assessment. Locatable mineral resources include a wide variety of rare and valuable "hard-rock" minerals like gold and silver. Leasable mineral resources include a list of specific "soft-rock" minerals, including crude oil, natural gas, coal, oil shale, gilsonite, sodium and potassium, and phosphate. Salable minerals are any other type of mineral material, not considered to be either locatable or leasable. Salable minerals include "common variety" materials like sand and gravel, landscaping boulders, dimension stone, rip-rap, and so on.

Agency Policy and Forest-Level Discretion

It is the policy of the Forest Service to "foster and encourage" responsible minerals development. Energy and mineral resources provide the raw materials that support all aspects of modern society and technology. Without reasonable and continued access to these resources, modern societies would ultimately revert to stone-age or pre-stone-age conditions. Proper management for each type of energy or mineral resource requires consideration of applicable laws and agency regulations, coordination with several other Federal or State agencies, and valid existing mineral rights (mining claims, mineral leases, and private mineral rights).

The Forest Service has considerable discretion in managing salable minerals within National Forest System lands, and allows much of that discretion to occur at the individual forest level. However, management of energy and locatable and leasable mineral resources is governed by numerous laws and regulations, and is not particularly discretionary at either the agency or forest level. Ownership of valid federal mining claims and federal mineral leases conveys legal real-property rights for reasonable exploration, development, and removal of the mineral resources in question.

Laws Applicable to Mineral Development

Starting with the General Mining Law of 1872, a string of federal laws and regulations govern energy and minerals activity on federal lands, a few of which are briefly described below. Many of these laws predate creation of the US Department of Agriculture and Forest Service. The 1872 Mining Law set forth the principles and process for private citizens to locate and obtain federal mining claims, on lands reserved

from the public domain (including those subsequently included in the National Forest System). This process allows private citizens to obtain mineral rights to locatable mineral resources on federal lands. The Organic Act of 1897 provided for the continuing right to conduct mining activities on National Forest System lands. The Mineral Leasing Act of 1920 addressed leasable minerals and gave authority to the Secretary of the Interior to lease certain kinds of mineral resources within National Forest System lands. For both locatable and leasable minerals, the BLM manages the federal mineral estate (federal mining claims and federal mineral leases), even where the surface estate is otherwise managed by the Forest Service or others. The Multiple-Use Sustained Yield Act of 1960 directed National Forests to consider the relative values of all resources, including mineral resources. The Federal On-shore Oil and gas Leasing Reform Act of 1987 says that the Secretary of Interior may not issue any mineral lease on National Forest System lands over the objection of the Secretary of Agriculture. The Forest Service must conduct a leasing analysis to decide which lands should be made available to the Secretary of Interior for future mineral leasing. Each of these laws, coupled with subsequent and relevant agency regulations, sets forth appropriate conditions and restrictions for proper management and development of the different mineral resources. Questions on proper management of mineral resources is therefore already largely decided and prescribed at or above the Forest Service level, and above the level of individual Forests or Forest Plans. As such, additional restrictions or directions at the Forest and Forest-Planning Level are generally not needed, as they either needlessly duplicate existing laws and regulations, or conflict with case law and valid existing mineral rights of mining claim or mineral lease holders.

Existing Information - Sources and Gaps

The following information sources were used in preparation of this part of the assessment, and were cited by the text.

- Boden, T., and Tripp, B.T., 2012, Gilsonite veins of the Uinta Basin, Utah: Utah Geological Survey Special Study 141, 50 p.
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- Cheney, T.M., Smart, R.A., Waring, R.G., and Warner, M.A., 1953, Stratigraphic sections of the Phosphoria Formation in Utah, 1949-51: U.S. Geological Survey Circular 306, 40 p.
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- USGS, 2017. United States Geological Survey (USGS Earthquake Hazards Program Website. Searched and Accessed April 2017 (https://earthquake.usgs.gov/)
- Wikipedia, 2016. Accessed October 25, 2016 (https://en.wikipedia.org/wiki/Flaming_Gorge_Dam)
- Wyoming Geological Survey, 2014. Wyoming Trona. Summary Report 2014.

Gaps in the available information include:

- Names, history, and production from some of the abandoned mines
- Geologic mapping at a scale more detailed than 1:100,000

Scale of Analysis

The spatial scale of analysis, or planning area for this assessment, includes all lands within the exterior boundary of the Ashley National Forest. When discussing the broader landscape, this assessment primarily focuses on Duchesne, Uintah, and Daggett Counties in Utah, for areas of the Forest within the Uinta Basin and High Uinta Mountains - and on Sweetwater County in Wyoming, for areas of the Forest within and around the Flaming Gorge National Recreation Area. When discussing the economic scale of analysis for energy and mineral uses on the Ashley National Forest, the planning area expands to municipalities providing services to the local energy industry. These areas include Duchesne, Roosevelt, Vernal, and other surrounding municipalities.

Existing and Current Conditions and Trends

The following sections list and discuss the existing and current conditions and trends for each resource type, including management regulations, resource types and definitions, types of resources available on the Ashley National Forest, development status of the various resources, and public or industry interest. First will be a discussion on general information applicable to most types of energy and mineral resources, followed by the descriptions and discussions of specific resource types.

General Information

Demand for energy and minerals exploration and development within the planning area, and the subsequent need for management of those activities, is directly related to the exploration and development proposals generated by the public and industry. These proposals are related to fluctuations in global demand and prices for various energy and minerals products. Although different sources of energy have different costs and challenges, they all produce essentially similar and related products. Mineral resources are very different, in that different mineral resources or types can produce or provide widely different products, each with independent fluctuations in global demands, prices, and uses. Management of mineral

resources is therefore primarily dependent on and responsive to these global demands, prices, and uses, rather than on long-range Forest or agency planning or expectations. Management of mineral resources therefore poses programming and scheduling challenges that are not common with other Forest Service resources or programs. Careful coordination with numerous other public agencies and minerals industry representatives is required. This is because responsibility for minerals management overlaps with, or in some cases is primarily managed by, other agencies. Development proposals and demands for responsible mineral and energy development also come from industry, and not from agency goals, plans, or budgets.

Energy and minerals resources are very important to the citizens and governments surrounding the Ashley National Forest. This was documented in a 2008 survey conducted by Utah State University (Krannich, 2008). For Daggett, Duchesne, and Uintah Counties, 89 percent of residents considered development of energy resources on public lands to be “very important” or “moderately important”. For those same counties, 79 percent of respondents felt that mineral exploration and extraction on public lands should experience a "major increase”, a “moderate increase” or “stay about the same”. For those same counties, 79 percent of respondents also felt it was "very important" or “moderately important” for sand, gravel and other minerals to be developed from public lands.

Every kind of energy and mineral resource has its own unique issues, drivers, stressors, and management needs. These can lead to fluctuations in the scale of exploration or development of specific resources, fluctuations in the level of management needed for each resources, or changes in the types of needed management actions or concerns over time. The dominant and foreseeable trends and issues for each resource type are described in the appropriate section for that resource. Trends and drivers dramatically impacting development of one kind of energy or mineral resource might have similar impacts, might have opposite impacts, or might have no impacts on other different kinds of resources.

Renewable Energy

Renewable energy resources include resources such as solar power, hydropower, wind energy, biomass, and geothermal energy. These resources are typically managed under special use permit, per Forest Service regulations at 36 CFR 251.53. Regulations for geothermal power are found at 43 CFR 3201. Renewable energy sources are considered renewable because extraction of energy from these sources does not exhaust the energy source or preclude similar energy extraction at another date. These energy sources continue to be available over time. This is in contrast to nonrenewable energy sources, which once used can no longer supply additional energy, or are replenished only slowly over geologic time.

The primary type of renewable energy associated with the Ashley National Forest is hydropower, with a large dam at Flaming Gorge Reservoir, and a few smaller reservoirs that also generate power. The Flaming Gorge Dam is operated by the Bureau of Reclamation and is located within the Flaming Gorge District of the Ashley National Forest. The dam generates large amounts of renewable energy, with annual production of about 344,000 MWh (Wikipedia, 2016). Small hydropower operations also exist at Yellowstone Lake and in Uinta Canyon, both within the Roosevelt District of the Ashley National Forest. Several other reservoirs exist on the Forest, but do not produce hydropower. Additional opportunities for hydropower generation exist due to large topographic variations across the Forest. However, the amount of hydropower potentially available is small, relative to other potential energy sources.

Many of the oil and gas wells on the South Unit of the Duchesne District of the Ashley National Forest have potential for production of geothermal energy. However, the available temperature ranges are low (minimal power to be extracted) compared to other geothermal areas in the country. Also, the main focus of such wells is the production of crude oil and natural gas. When those wells are no longer productive for oil and natural gas, they could become productive for generating small amounts of geothermal energy (Herron, 2016).

Other forms of renewable energy, such as wind power, solar, geothermal and biomass energy have not seen similar interest or development within the Ashley National Forest. This is partially due to the low potential for these resources relative to other areas in the country. It is also because of competition from abundant nonrenewable energy sources such as crude oil, natural gas, and coal in the immediate and surrounding areas.

There are many drivers for increased or decreased demand or development of renewable energy resources. These include fluctuations in the cost or availability of energy extracted from other sources, fluctuations in local and global populations, government subsidy or public demand for renewable energy sources, public concerns and future regulations relative to carbon dioxide emissions and carbon credits, and fluctuations in national and global demand for energy.

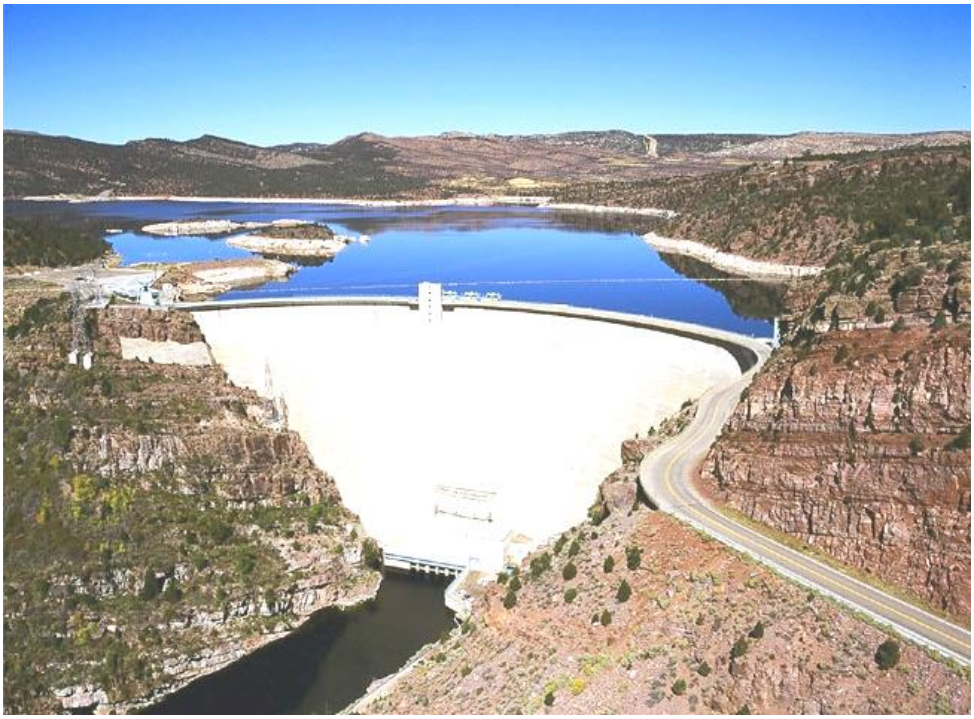


Figure 1. Flaming Gorge Dam and Reservoir

Nonrenewable Energy

Nonrenewable energy resources include things like crude oil, natural gas, coal, tar sand, and oil shale. Although the Forest Service manages the surface resources and disturbances, the BLM typically manages the actual energy resources, via their agency regulations at 43 CFR 3100 (oil and natural gas), 43 CFR 3420 (coal), 43 CFR 3140 (tar sand), and 43 CFR 3900 (oil shale). Forest Service management of surface disturbances associated with these resources is guided by agency regulations at 36 CFR 228, Subpart B (solid leasable minerals) and Subpart E (oil and gas).

The Ashley National Forest contains abundant nonrenewable energy resources, all of which are classified and managed as leasable minerals. They are discussed further under that heading below (along with other leasable minerals).

Leasable Minerals

Leasable minerals are those mineral resources specifically described by the Mineral Leasing Act of 1920, as amended. Leasable minerals are sometimes called "soft rock" minerals, and include sodium, potassium, phosphate, crude oil, natural gas, coal, oil shale, and others.

Leasable mineral resources are leased and managed by the BLM, under authority of the Secretary of the Interior, even when they occur on or beneath National Forest System lands. In such cases, the Forest Service is responsible for managing surface operations and resources, while the BLM is responsible for managing the minerals, leases, and subsurface operations. Prior to BLM leasing of such minerals, the Forest Service must decide what National Forest System Lands to make available to the BLM for subsequent leasing. The Forest Service must also decide, and provide to the BLM, any lease stipulations deemed necessary by the Forest Service for protection of other Forest resources and values. Forest Service regulations and direction governing management of leasable minerals are found at 36 CFR 228, Subparts B (solid leasable minerals) and E (oil and gas). Federal mineral leases are managed by the BLM.

The 1986 Forest Plan provided direction for leasable mineral development and leasing, but imposed few additional restrictions beyond those already decided by law or regulation. In 1997, the Forest Plan was amended by the 1997 Western Uintah Basin Oil and Gas Leasing EIS and Decision. This change made large portions of the South Unit area administratively available to the BLM for oil and gas leasing. It also established lease stipulations to be applied to future oil and gas leases within the Ashley National Forest. The 1986 Ashley forest plan was also amended by the 2015 greater sage grouse Environmental Impact Statement and Record of Decision, which added guidance for leasable minerals development within sage grouse habitat.

The Ashley National Forest contains a wide variety of leasable minerals, including crude oil, natural gas, coal, tar sand, oil shale, gilsonite and elaterite (hard natural hydrocarbon tars), sodium minerals, and phosphate. The different kinds of leasable minerals will be briefly discussed below. However, only the crude oil, natural gas, sodium, and phosphate resources appear to have economic potential for current or near-future development on the Ashley National Forest.

Crude Oil and Natural Gas

There are considerable crude oil and natural gas resources within the South Unit of the Duchesne District of the Ashley National Forest. These resources are usually discussed together because they typically occur and are produced together, along with variable amounts of byproduct water. Most of the interest and development of oil and gas resources within the Ashley National Forest has occurred in the eastern half of the South Unit. There is also potential for crude oil and natural gas resources along the northern and southern margins of the Uinta Mountains, and within portions of the Flaming Gorge National Recreation Area. These areas of the Forest have seen little or no development to date. Other areas of the Ashley National Forest generally have little or no potential for crude oil and natural gas resources.

The Forest Service 1997 Western Uintah Basin Oil and Gas Leasing EIS and Decision made most of the South Unit of the Duchesne District available to the BLM for oil and gas leasing. The BLM subsequently issued a large number of individual oil and gas leases to various entities. The 1997 Leasing EIS estimated that approximately 35 oil and gas wells would likely be developed over the subsequent 10 year period. That estimate remained close to reality, within the projected 10-year period. However, subsequent rises in crude oil and natural gas prices have led to considerable increases in both proposals and developments for oil and gas resources within the Ashley National Forest.

All active oil and gas leases and developments on the Forest are within the eastern half of the South Unit. Although ownership of individual leases varies, oil and gas leases are currently controlled by either Berry

Petroleum (about 25,900 acres) or Vantage Energy (about 49,500 acres). Active federal oil and gas leases on the Ashley National Forest are shown on Plate 1. For information on specific oil and gas leases, contact the Utah BLM State office.

The Ashley National Forest currently has 160 active or semi-active oil and gas wells, drilled and operated from 51 well pad locations. Of those, 156 wells were drilled from 47 well pad locations, and are operated by Berry Petroleum. The other 4 wells were drilled from 4 well pad locations (only 1 actively producing), and are operated by Vantage Energy. Berry Petroleum currently produces about 316,000 barrels of crude oil, 58,000 barrels of natural gas liquids (condensate), and 1.5 million cubic feet of natural gas per year, from wells on the Ashley National Forest (Hoopes, 2016).

Figure 2. Oil and gas developments on the Ashley National Forest

Starting in early 2014, a dramatic drop in crude oil prices stopped or delayed all new oil and gas developments on the Forest. In addition to the existing developments, about 50 additional oil and gas wells have technically been proposed and approved for development, but have not been drilled. These include 31 proposed wells for Vantage Energy, and 19 proposed wells for Berry Petroleum, along with needed well pads, access roads, and gas pipelines. In addition, Berry's 2007 Master Development Plan, for development of their oil and gas leases on the Ashley National Forest, includes another 200+ wells that have not yet been proposed or evaluated in site-specific detail. Whether any of these additional wells are ever drilled depends on interest by Berry Petroleum and Vantage Energy, as well as future market prices and demand for crude oil and natural gas.

Much of the South Unit has good potential for crude oil and natural gas resources, including areas not currently under active oil and gas leases. However, most of those promising but unleased areas are steep and rugged, such that oil and gas development would be difficult or prohibited by applicable lease stipulations. Although the 1997 Western Uintah Basin Oil and Gas Leasing EIS and Decision made most of the South Unit open and available for oil and gas leasing, that decision is now approximately 20 years old and essentially obsolete. Among other things, the 1997 leasing decision does not take into account the

2001 roadless rule, or the 2015 decision regarding sage grouse and sage grouse habitat. A new oil and gas leasing analysis will likely be needed for any future oil and gas leasing on the Forest. Any new leasing analysis would need to accommodate changes since the 1997 leasing analysis, to determine the appropriate lease stipulations for future leases. At the time of this assessment, the Ashley National Forest intends to begin a new oil and gas leasing analysis, following and pending completion of a new Forest Plan.

Coal

Although several coal deposits are known or suspected to occur within the Ashley National Forest, they are either prohibitively deep or are too small for significant economic development. Large coal deposits near Price, Utah are suspected to continue northward at great depth, beneath the western portions of the South Unit of the Ashley National Forest. Such deposits are speculative, and the great depth likely prohibits exploration or development of these potential resources.

Small coal deposits of various thickness and quality have been documented from several rock units along both the South and North slopes of the Uinta Mountains. Only a few of these overlap the Ashley National Forest, and most were not of sufficient thickness or quality to justify mining. None are currently considered to be economic. See Doelling and Graham (1972) for more information of the documented coal occurrences within or adjacent to the Ashley National Forest. Small undocumented exposures of coal have also been reported from Coal Draw, in the Farm Creek area of the Roosevelt District. Little is known about these deposits.

Tar Sand

Tar sands are simply porous sandstones or other rocks, where the pore spaces in the rocks are filled with solid to semi-solid crude oil or tar. There are tar sand deposits tar sand deposits near the mouth of Whiterocks Canyon, on the Vernal District. There are also smaller uneconomic and undocumented tar sand outcrops on or near Reservation Ridge, within the South Unit of the Duchesne District.

The tar sand deposits near Whiterocks Canyon occur on both sides of the Forest Boundary. An inactive commercial open pit mine for tar sand is located on private land immediately adjacent to the Ashley National Forest. Materials removed from the mine were used as natural asphalt for paving local roads. The tar sand deposits also occur or continue onto the Ashley National Forest, but have not been leased for exploration or development.

Tar sands deposits within the South Unit are related to the crude oil from the same area. Crude oil from the South Unit typically contains a large fraction of wax, and is solid or semi-solid at room temperature. Where porous rock layers are saturated with waxy crude oil, and those rocks are exposed at the surface at room temperature, the oil-soaked rocks would be considered tar sand deposits. Within the South Unit, these deposits are small and intermittent, and of little economic value compared to large deposits elsewhere.

For more information on Tar Sand deposits within the Uinta Basin area, both on and off-Forest, see the BLM (2012), or Blackett (1996).

Oil Shale

The Ashley National Forest includes large areas with known or suspected deposits of oil shale. These deposits occur within the Green River Formation, beneath large portions of the Flaming Gorge District, and beneath large portions of the South Unit of the Duchesne District. Although widespread, the known oil shale deposits within the Ashley National Forest are relatively thin and impure. Much thicker and

richer oil shale deposits occur on BLM administered lands near Bonanza, Utah, the White River Gorge, and elsewhere. See the BLM 2012 Oil Shale & Tar Sands Programmatic EIS for more information on oil shale resources. Any large-scale commercial development of oil shale resources would likely start with the thicker and richer oil shales located elsewhere.

Gilsonite and Elaterite

Several small deposits of gilsonite or elaterite (naturally hydrocarbon tar-like materials) are known to occur on the Ashley National Forest, but are poorly documented. The known deposits are either prohibitively small for development, compared to much larger deposits elsewhere in the Uinta Basin, or appear to be largely exhausted. It is possible that additional undiscovered gilsonite or elaterite deposits remain to be discovered. If so, they would likely be of similar size, and in the same general areas. For more information on documented Gilsonite deposits within the Uinta Basin area, see Boden and Tripp (2012).

Sodium Minerals

An enormous deposit of trona (a leasable sodium mineral) occurs at depth within rocks of the Green River Formation, adjacent to and partially underneath the Flaming Gorge National recreation Area. With an estimated 127 billion tons of trona, this constitutes the largest known trona deposit in the world (Wyoming Geological Survey, 2014). The trona is mined and processed to produce soda ash (sodium carbonate), an important industrial chemical used for a wide variety of products. The deposits consist of layered beds of trona, at depths of 800 to 2,200 feet below the ground surface, sandwiched between other rock layers. In 2013, mining operations near Green River Wyoming produced more than 16 million tons of trona, employing 2,328 people and supplying approximately 90 percent of United States demand for soda ash (Wyoming Geological Survey, 2014). Mining operations are conducted underground via several different mining methods (room and pillar, longwall, solution mining).

All trona mining operations, and associated surface facilities, lie outside of the Ashley National Forest. However, about 40 acres of the Ashley National Forest is covered by an active sodium mineral lease, within the SE quarter of Section 12, T16N R109W. The known and minable trona beds continue underneath portions of the Flaming Gorge District of the Ashley National Forest. When the Flaming Gorge National Recreation Area (NRA) was created, it was recognized that large and potentially valuable trona deposits existed beneath portions of the NRA surface. The NRA was deliberately left open to future minerals leasing on the condition that any future leases or lease developments would have no surface disturbances or facilities within the NRA.

Because of the depth to the known trona beds, these resources could likely be developed beneath the NRA, via surface facilities located on adjacent private or BLM lands. However, it is not expected that trona mining operations would extend beneath the NRA for many years to come. At current production rates, the known trona reserves are expected to last more than 2,000 years (Wyoming Geological Survey, 2014).

Various other sodium minerals and deposits are known to exist, in impure beds and sub-economic quantities, within rocks of the Saline Facies of the Green River Formation. These rock layers underlie portions of the South Unit of the Duchesne District. There is little interest in these potential sodium deposits, as they appear to be uneconomic at current market prices.

Phosphate

A large phosphate deposit is being actively mined in the Brush Creek Area, north of Vernal, on lands immediately adjacent to the Ashley National Forest. The phosphate ore occur within portions of the

Meade Peak Member of the Permian-age Park City Formation. This mining operation currently produces about 4 million tons of phosphate ore per year, and employs about 560 people (160 at the mine, and 400 at a processing plant at Rock Springs Wyoming) (Spencer, 2016).

Although phosphate mining is not taking place within the Ashley National Forest, past mining has continued right up to the Ashley National Forest boundary, and similar phosphate deposits are known to occur nearby and elsewhere on the Forest (Herron, 2016). On the South Slope of the Uinta Mountains, phosphate deposits can be found or traced from Burnt Cabin Gorge to Dry Fork Canyon, with intermittent outcrops of similar phosphate material continuing westward for many miles. Similar phosphate rocks also occur intermittently along the north slope of the Uinta Mountains, from Bare Top Mountain on the east, to near Hole in the Rock on the west (Herron, 2016). These north-slope phosphate deposits are only poorly explored, but are similar to the phosphate deposits being mined in the Brush Creek area on the south slope.

There are currently no phosphate leases on the Ashley National Forest. However, the BLM has received requests for phosphate leasing on the Ashley National Forest in recent years. For additional information on phosphate deposits in Utah, located both on and off the Ashley National Forest, see Cheney (1957) and Cheney and Others (1953). For geologic maps showing phosphate-bearing rock units, see Sprinkel (2006) and Sprinkel (2007).

Trends and Drivers for Leasable Minerals

The future scale and nature of leasable minerals exploration and production within the Ashley National Forest is largely dependent on fluctuations in future global market prices and industry proposals. Such changes include interest and investment by mining or energy companies, new resource discoveries, new market commodities, new uses for existing mineral resources, political pressures or new laws favoring or disfavoring certain mineral resources, and changes in mineral discovery or recovery technology.

Leasable minerals specifically valued for nonrenewable energy production (crude oil, natural gas, coal, oil shale, and tar sand) have additional energy-related issues and drivers. These include fluctuating demands for energy, availability and economics of competing energy sources, government subsidy of renewable energy sources, public concerns or regulations for carbon dioxide emissions and carbon credits, and fluctuations in national and global economies and populations.

A change in price or development for one type of mineral resource does not always correlate well to similar changes or prices for other types of minerals. This is because some leasable mineral commodities are quite different from the others. Therefore, while a large rise in the price of phosphate might lead to a dramatic rise in exploration or development for phosphate, it might not correlate in any way to similar exploration or development for crude oil.

The timing for wholly new leasable mineral developments and proposals is generally much slower than for locatable minerals. This is because leasable mineral resources must first be leased, before they can be explored or developed. Any new mineral leases on the Ashley National Forest must first be evaluated by the Forest Service and BLM before those leases could be sold or developed.

Locatable Minerals

Locatable minerals are sometimes called "hard rock" minerals and may include deposits of gold, silver, lead, zinc, copper, molybdenum, uranium, gypsum, chemical-grade limestone, and other rare or high-value minerals and metals. Locatable minerals technically include any valuable mineral deposits that are subject to exploration and production under the US General Mining Law of 1872, as amended. The 1872 Mining Law set forth the principles and process for private citizens to locate and obtain federal mining

claims, on lands reserved from the public domain (including those subsequently included in the National Forest System). Forest Service regulations and direction governing management of locatable minerals are found at 36 CFR 228, Subpart A.

By law, citizens have the right to explore for locatable mineral deposits, and locate mining claims over such deposits, on all federal owned lands not specifically withdrawn (closed to mining claims). Valid federal mining claims are needed before locatable minerals can be developed or extracted from National Forest System lands. Federal mining claims are managed by the BLM, but the Forest Service manages all surface operations and facilities for locatable minerals on National Forest System lands. The Forest Service is the surface-management agency and is responsible for protecting surface resources and other values during mineral exploration and extraction activities conducted on National Forest System lands. The Forest Service manages these activities through approval of plans of operations, and review of notices of intent, to verify that proposed activities are reasonable, and to assure appropriate reclamation and protection of other surface resources.

Locatable Minerals on the Ashley National Forest

Compared to other National Forests, the Ashley contains relatively small amounts of widely scattered locatable minerals, due to the local and regional rock layers and geologic history. Many different rock units occur on the Ashley National Forest, representing a considerable range of geologic environments and ages. However, most of these rock units are sedimentary in nature, and are not promising for development of large locatable mineral deposits.

The 1986 Forest Plan allows for locatable minerals exploration and development, and imposed few additional restrictions beyond those already decided by laws or regulations. Since exploration and development activities for locatable minerals are already allowed, regulated, and proscribed by laws and Forest Service regulations, additional restrictions and guidance at the Forest and Forest-plan level are generally not needed. Additional restrictions at the Forest or Forest-Plan level would likely either duplicate or conflict with existing laws, restrictions, guidance, or rights.

Figure 3. Locatable Mineral Exploration on the Ashley National Forest

Information on active mining claims can be obtained from the BLM LR2000 lands database, accessed online at: http://www.blm.gov/lr2000/. As of 04-04-2016, there were 103 active mining claims on the Ashley National Forest. Individual mining claims typically cover 20 acres each, for a total of about 2,128 acres of active mining claims Forest-wide. Of the total claims, 0 claims (0 acres) were located on the Flaming Gorge District, 29 claims (about 599 acres) were located on the Vernal District, 34 claims (about 702 acres) were located on the Roosevelt District, and 40 claims (about 826 acres) were located on the Duchesne District. For up to date information on specific mining claims, claim locations, status, or owners, contact the Utah BLM State Office, or see the BLM LR2000 Database (BLM, 2016).

The Ashley National Forest is open to mining claims essentially anywhere that has not been formally withdrawn (designated as closed to federal mining claims or mineral leases), and is not acquired land (private land subsequently purchased by the federal government). Large minerals withdrawals within the Ashley National Forest include the High Uintas Wilderness (about 274,000 acres within the Ashley portion of the Wilderness area) and the Flaming Gorge National Recreation Area (about 190,600 acres). Numerous smaller minerals withdrawals also occur on the Ashley National Forest. These smaller withdrawals are mostly associated with large reservoirs, canyon bottoms where large reservoirs were anticipated, and the surface overlying water diversion tunnels. Mineral withdrawals are designated and managed by the BLM, and can be viewed on BLM Land Status Plats. For additional information on mineral withdrawals, or locations of specific withdrawals, contact the Utah or Wyoming BLM State office.

Recent or Current Locatable Minerals Operations

Approved active or recent locatable minerals operations on the Ashley National Forest (in no particular order) include the following:

- The Limestone Mine, in the Diamond Mountain area of the Vernal District. This is an active open pit mine, producing chemical-grade limestone, used primarily for de-sulfurization of smokestack gasses at the Deseret Power Plant. Production of locatable limestone from the mine is approximately 63,700 tons per year (Dixon, 2016). The mine also produces a salable (less valuable, non-locatable) limestone byproduct, at a rate of about 7,400 tons per year (Dixon, 2016). This byproduct consists largely of road gravel, and is used by the Forest Service, local county governments, and others.
- The Honeycomb Mine, in the Blind Stream area of the Duchesne District. This is an intermittently active open pit mine, producing small tonnages of decorative calcite blocks. The calcite blocks are mined, transported off-site, and then cut and used for countertops, light fixtures, and other assorted decorative applications.
- The Amber Onyx Mine, in the Blind Stream area of the Duchesne District. This is a proposed open pit mining operation, similar in scale and nature to the Honeycomb Mine. However, at the time of this assessment, mining operations at the Amber Onyx Mine have not yet begun. When or if operating, this mine is expected to produce small tonnages of decorative calcite blocks, similar to those from the Honeycomb Mine.
- Dal Cuinn Exploratory Drilling Project, in the Dry Ridge area of the Duchesne District. This is a small-scale exploratory drilling program, seeking to demonstrate and explore a small disseminated copper-silver deposit in the Dry Ridge area. There is intermittent ongoing exploration activity, but no production or significant disturbance at the site.

- Iron King Exploratory Drilling Project, in the Pole Mountain / Farm Creek area of the Roosevelt District. This is a small-scale exploratory drilling program, seeking for precious metals (primarily gold) in the Farm Creek Area. This project currently includes 1.6 miles of temporary road, and single exploration drill-hole that was drilled and plugged. The site is planned for reclamation, but as of August 2016, had not yet been reclaimed.
- Kenya's Quest Exploratory Drilling Project, in the Rock Creek area of the Duchesne District. This is a small-scale exploratory drilling program, looking for precious metals (primarily gold) in the Lower Rock Creek Area. This project was approved, but as of August 2016, had not begun active drilling operations.

In addition to active mining claims and approved exploration or mining operations, there are several areas on the Ashley National Forest where locatable minerals have been mined or explored for in the past. Some of these areas were not properly abandoned or fully reclaimed, and are described in more detail in the Abandoned Mines section of this report.

Potential Future Locatable Minerals

For the Ashley National Forest, potential future locatable mineral operations would likely include those minerals already being explored or produced or mined in the past. These could include deposits of chemical-grade limestone, small high-grade copper-gold replacement deposits (like the Dyer Mine), small lead-silver deposits (like those near Brush Creek and Dyer Mountain), low-grade disseminated copper-silver deposits (like those at Dry Ridge), or additional deposits of honeycomb-style decorative calcite.

In addition, the Ashley National Forest probably has potential for exploration and development of new and different locatable mineral resources in the future. Such resources could include gypsum beds in the Carmel Formation (if a local need for gypsum arose), uranium-REE-fluoride resources (in phosphate rocks), gemstones, zeolites, or clay minerals. A small occurrence of emeralds was reported from the Rock Creek area of the Duchesne District. Some areas of the Green River Formation, on the Duchesne and Flaming Gorge Districts, are known or likely to contain zeolite mineralization. Some areas of the Forest also contain shale units or altered volcanic ash beds, with potential for locatable clay deposits.

Treasure Hunting Activities

In addition to actual locatable mineral resources, there are abundant legends and folklore about Spanish-era mining activities within the Ashley National Forest. Persuaded by these legends, some people search for so-called Spanish mines, and for lost treasures left behind by early miners. Such operations are often disguised or imagined as locatable minerals operations, but seek for lost treasures and imaginary mines rather than actual locatable minerals. Review of local geologic conditions and rock units, and examination of purported Spanish-era mining sites, provides no valid or reasonable evidence to support these legends. Purported evidences for rich Spanish-era mines are easily attributed to other factors including misidentification of common minerals, natural geologic features, and early pioneer-era structures, often supported by fanciful story-telling or deliberate fraud (Herron, 2016). Actual structures and mineral developments, purported to be of Spanish origin, are generally associated with pioneer-era local production of quicklime and cement. Small deposits of locatable minerals do occur on the Ashley National Forest, but are very different from the purportedly rich Spanish-era mines asserted by local legends and folklore. The 1986 forest plan does not address management of treasure hunting activities, or distinguish them from valid locatable minerals operations.

Trends and Drivers for Locatable Minerals

Like leasable minerals, the future scale and nature of locatable minerals exploration and development within the Ashley National Forest is largely dependent on fluctuations in global market prices and

industry proposals. Such changes include interest and investment by mining companies, new resource discoveries, new market commodities, new uses for existing mineral resources, and changes in mineral discovery or recovery technology. The minerals themselves do not change significantly, but market prices, discovery of new deposits or recovery methods, and new uses for particular minerals can change significantly over time.

A change in the interest or development of one type of mineral commodity does not always correlate well to other types of minerals. This is because many locatable mineral resources are very different from others, and fill different needs by society. Therefore, while a large rise in the price of gold might lead to a dramatic rise in exploration for gold, it would not necessarily correlate in any way to exploration or development of limestone resources.

The proper scale of locatable minerals activities at any given time is entirely dependent on industry actions and proposals at that time, based on demand and market prices for the various resources. This is regardless of individual forest budgets, current or future plans, or hopes and expectations. Since the level of exploration and development for locatable minerals on the Ashley National Forest has historically been somewhat low and intermittent, it is likely to remain similarly low and intermittent for the foreseeable future.

Salable Minerals

Salable minerals include common-variety minerals such as sand and gravel, common clay, landscaping boulders, dimension stone, and similar materials. Salable minerals are used internally by the Forest Service, and are also available for removal and use by other agencies and private citizens through Forest Service sales and permits. Agency regulations governing management of salable minerals (mineral materials) are found at 36 CFR 228, Subpart C.

The management of salable minerals, although guided by laws and regulations, is largely discretionary at the individual Forest and Forest-plan level, unlike locatable and leasable minerals. Removal of salable minerals does not require mining claims or mineral leases, so the BLM is not involved in management of these materials on National Forest System lands.

The Ashley National Forest contains large amounts of salable minerals. Some of these materials are used internally by the Forest Service, for construction and maintenance of roads, campgrounds, and other Forest infrastructure. The Ashley National Forest typically uses about 6,500 tons of salable minerals per year for construction and maintenance projects. This material consists primarily of crushed and screened road gravel, barrier rocks, rip-rap, and general construction and maintenance material.

Salable minerals are also provided free of charge to local governments for public projects, and to the general public for small-scale non-commercial use. Salable minerals are also sometimes available, on a case-by-case discretionary basis, for sale to local commercial projects. The Ashley National Forest typically issues about 75 to 120 "free-use" rock permits each year to private citizens for their own personal non-commercial use. These permits typically allow removal of up to 1 to 3 tons of material each. The materials removed under free-use permits generally consist of sandstone flagstones, quartzite boulders, and river rocks, used for decorating and landscaping private local residences.

The Limestone Mine, previously described as a locatable minerals operation, also produces approximately 17,600 tons per year of less-pure salable mineral material. This salable material is a byproduct from production of chemical-grade locatable limestone. Some of this is used for concurrent reclamation of the open pit as mining progresses. However, approximately 7,400 tons per year of salable material from the Limestone Mine is crushed and screened for commercial sales, primarily as road base (Dixon, 2016).

Figure 4. Salable mineral resources on the Ashley National Forest

The trends and drivers for salable minerals on the Ashley National Forest are pretty simple. The largest use of salable minerals on the forest is for local construction and maintenance projects, by the Forest Service and other local agencies. Such uses fluctuate in volume from year to year, based on the needs for specific project needs, and based on agency priorities and budgets. However, these uses are likely to continue at similar levels for the foreseeable future. Changes to federal, county or state budgets for road or reservoir construction and maintenance projects could lead to similar changes in demand and production of salable minerals from the Ashley National Forest.

Abandoned Mines

Abandoned mines are generally locatable or leasable mineral sites, which were worked and abandoned long ago, without being fully reclaimed. Abandoned mine sites may have water quality issues, hazardous materials, or safety or stability issues from mine workings or facilities. In some cases, the original mine operator or other responsible parties can be found, to clean up problem sites. However, in many cases, the original mine operator or responsible parties cannot be found.

Management and reclamation of abandoned mines generally falls under agency regulations at 36 CFR 228 Subpart A (locatable minerals) or Subpart B (solid leasable minerals). However, other laws and regulations (for example CERCLA) can also apply.

Figure 5. Abandoned mine adit on the Ashley National Forest

The Ashley National Forest includes several areas with abandoned mineral exploration or development sites. Most of these site are tiny hand-dug prospecting pits, with no significant concerns or hazards. However, a few have larger pits, bulldozer cuts, or underground workings that could be reclaimed. Such areas are scattered widely across the Ashley National Forest and include the following, in no particular order:

- Dyer Mine, near the top of Dyer Mountain, on the Vernal District. This mine was developed on a small high-grade copper-gold sulfide replacement deposit, within a limestone host rock. Several adits and small open pits were developed. Most of these sites occur largely on patented mining claims surrounded by the Ashley National Forest, and most of them have been reclaimed. A few small prospect pits occur on Ashley National Forest surface, but appear to be of little consequence. The Dyer Mine reportedly produced only 300 tons of hand-picked ore, during the time period 1886 to 1901. The ore reportedly ran as high as 49 percent copper, 27 ounces per ton silver, and 0.26 ounces per ton gold (Utah Geological Association, 2005).
- Several bulldozer cuts and prospect pits on the south slope of Dyer Mountain, on the Vernal District. These developments are mostly on private patented mining claims, surrounding by the Ashley National Forest. These developments explore irregular lead-silver sulfide and lead carbonate deposits in a limestone host. Production prior to 1947 consisted of 12 tons of hand-picked ore, running 25 percent lead, 17 percent zinc, 1.5 percent copper, 2 ounces per ton silver, and 0.02 ounces per ton gold. In 1947, an additional 34 tons of ore was produced, of unknown but probably similar grade (Utah Geological Association, 2005). These old workings are not considered hazardous, but the naturally occurring levels of lead and zinc and other metals might pose an environmental concern (Herron, 2016).
- Several adits and prospect pits in or near the bottom of Brush Creek, on the Vernal District. These old mine workings explore small deposits of lead sulfide and lead carbonate, in a limestone host rock. These developments are small and remote, and are not considered a significant hazard.

- An adit, several bulldozer cuts, and several shallow drill-holes, occur in the Grizzly Ridge area of the Vernal District. These mining developments were exploring irregular lead-silver and lead carbonate deposits in a limestone host rock. There has been no known production from these workings.
- Indian Canyon Elaterite Mine, in Left Fork Indian Canyon area, on the Duchesne District. This is an abandoned mine adit, from which a large but unknown amount of elaterite (a naturally occurring gilsonite-like hydrocarbon tar) was produced. When the mine was operating, at an early but unknown date, the material would have been classified as a locatable mineral. Today, the ore material would be classified as a solid leasable hydrocarbon, similar to coal or oil shale.
- Two partially collapsed adits, in the Blind Stream area of the Duchesne District. Two small adits that explore sandy impure limestone, presumably for low-grade gold deposits. No known production. These adits are hazardous, and should be closed (Herron, 2016).
- The Dutch John mine, in the Dutch John area of the Flaming Gorge District. This is an old exploratory mining site with several shafts and dozer cuts, chasing and exploring narrow deposits of copper carbonate ore in a fractured quartzite host rock. This site has been largely reclaimed, and is no longer considered hazardous. There has been no known production from these workings.
- Several bulldozer cuts and prospect pits, west of Heller Lake, in the Roosevelt District. These developments appear to be exploring low-grade lead-silver mineralization, or possibly other metals, in a black shale. There has been no known production from these workings. They are not considered hazardous.
- The Paint Mine, west of Moon Lake, on the Duchesne District. This site includes a small collapsed adit, several bulldozer cuts, and several exploration drill-holes. The workings and drill holes explore an irregular hematite replacement deposit in limestone. The miners were apparently exploring first for low-grade gold, then for copper, and then for hematite (for use as a red paint pigment), before the site was finally abandoned as uneconomic. This same site was apparently used by members of the Ute tribe and their ancestors, both historically and pre-historically, as a source of red hematite pigment.
- The Iron Mine, west of the North Fork Duchesne River, on the Duchesne District. This site includes several bulldozer cuts and small pits, partly on private patented mining claims, and partly on the Ashley National Forest. The mine workings explore irregular replacement deposits of hematite and magnetite in a limestone host rock. Production is believed to have been limited to several hundred tons of ore, of unknown quality, in the late 1940s or early 1950s (Utah Geological Association, 2005). These workings are not considered hazardous.
- Numerous small isolated prospect pits and adits, scattered across the southern slope of the Uinta Mountains, on the Duchesne, Roosevelt, and Vernal Districts. These small pits and adits typically explore small hematite replacement deposits and iron-rich paleo-karst sediments, in a limestone host rock. These workings were created at various times, by unknown prospectors, in hopes of finding gold or other locatable metals. The deposits typically contain iron oxides with only traces of valuable metals (Herron, 2016, Utah Geological Association, 2005). The prospect pits are typically small, and the adits are collapsed or very remote. Although some of the deposits do contain hazardous amounts of heavy metals, they are small and of little environmental risk (Herron, 2016).

The trends and drivers for abandoned mine sites are straightforward. New and current mining operations have much higher standards and restrictions than those operated many decades ago. Reclamation bonds are required for all current significant mineral operations, and inactive sites are being reclaimed when no longer active or needed. Therefore, the number of abandoned mine sites are expected to slowly decrease

over time. Existing abandoned mine sites will continue to be reclaimed by the Forest Service, or allowed to continue reclaiming themselves, as appropriate and as time and budgets allow.

Geologic Hazards

There are many types of geologic hazards that can pose a risk to people and infrastructure. Geologic hazards are naturally occurring, and result from different local or regional geologic conditions, including regional tectonic and volcanic activity, type and strength of local bedrock units, presence of subsurface voids or hazardous gasses, local climate, and the presence of steep topographic slopes. There are several types of geologic hazards known or suspected to occur on the Ashley National Forest. These include debris flows and landslides, rock-fall, snow avalanches, earthquakes, karst collapse and flooding, radon, hydrogen sulfide, and methane. Some of these hazards are discussed in more detail below.

The 1986 Ashley Forest Plan contains minimal guidance for management of geologic hazards. The 1997 Western Uintah Basin Oil and Gas Leasing EIS and Decision, which amended the 1986 Forest Plan, specifically prohibits oil and gas development in areas with steep slopes, unstable soils, or geologic hazards. Federal laws and agency regulations provide some guidance for geologic hazards, noting that hazard zones should be identified, that infrastructure should avoid known hazard zones, and that best practices and common sense should be used to avoid or mitigate known or suspected geologic hazards.

Debris Flows and Landslides

The Ashley National Forest contains several geologic units that are prone or susceptible to debris flows and landslides. These units tend to be weak, clay-rich, and/or poorly drained. Some geologic units have also been recently pushed or cut by glaciers into steep unstable slopes. Geologic units on the Ashley National Forest that are susceptible to landslides and debris flows include the Red Pine Shale, Humbug Formation, Chinle Formation, Morrison Formation, Cedar Mountain Formation, Mancos / Baxter Shale, Green River Formation, Uinta Formation, and various Holocene-age glacial till deposits.

Maps showing areas of the Ashley National Forest with bedrock units susceptible to landslides and debris flows, and with large pre-historic landslides, are included in this report as Plates 2 through 5. These maps do not cover the Wyoming portion of the Flaming Gorge District because GIS geology data in not readily available for the Wyoming portion of the Ashley National Forest. Most of the Wyoming portion of the Flaming Gorge District is underlain by bedrock of the Green River Formation, which is considered susceptible to landslides and debris flows. However, most of the Wyoming portion of the Flaming Gorge district also has very low slope angles, where significant landslides and debris flows would not be expected, despite the weak bedrock units.

The actual risk of landslides and debris flows, in areas with susceptible geologic units, depends on various other factors. These factors include slope angles, bedding angles, fracture density and faulting, groundwater pressure, surface water infiltration, and surface vegetation cover. Under the right conditions, landslides and debris flows can occur in areas underlain by resistant and competent rocks types, or in soils covering such rock types. Similarly, susceptible rocks are unlikely to generate significant landslides or debris flows where slope angles are low. Vegetation tends to stabilize shallow soils, delay water infiltration, and remove pressure from shallow groundwater. Areas where vegetation has been removed or killed by recent fires are typically more prone to landslides and debris flows.

Figure 6. Damage from a recent debris flow on the Ashley National Forest

Compared to pre-historic landslides and debris flows, evident from geologic maps and landforms, the historical debris flows and landslides on the Ashley National Forest have been relatively few and small. Recent historical events include:

- May 2005: The 2005 U-Bar Ranch Debris Flow. A rapid and destructive debris flow, created by groundwater saturation of shale bedrock and unconsolidated glacial till, above an over-steepened slope. Rapid snowmelt in May of 2005, following an unusually heavy winter snowpack, led to failure, liquefaction, and flow of the shale bedrock and overlying glacial till. The resulting debris flow picked up velocity and additional debris from the over-steepened slope, and destroyed a small cabin, damaged several structures, and obstructed and buried portions of a road and hiking trail.
- July 2007: The 2007 U-Bar Ranch Debris Flow. A destructive but smaller debris flow, following the same pathway as the earlier 2005 flow. Heavy summer rainfall lead to re-saturation and liquefaction of the previously failed bedrock and de-vegetated debris related to the earlier debris flow. This debris flow impacted several small structures, and again obstructed portions of a road and hiking trail.
- May 2011: The 2011 Brownie Canyon Debris Flow. A rapid and destructive debris flow, created by groundwater saturation of shale bedrock and pre-historic landslide debris, above a steep slope. A heavy snowpack followed by rapid snowmelt in May of 2011 led to groundwater saturation and failure of weathered shale and soils, within a large prehistoric landslide area. The debris flow buried portions of the Brownie Canyon Road, and dumped large amounts of rock, soil, and coarse woody debris in Brownie Creek. The prehistoric landslide is much older, and appears to have been a large rotational slump failure.
- June 2015: The 2015 U-Bar Ranch Debris Flow. A small debris flow, following a similar pathway to much larger and more destructive flows in 2005 and 2007. This small debris flow was initiated by heavy rainfall onto unstable slopes and debris related to the earlier debris flows. At a break in slope above the U-Bar Ranch area, the 2015 debris flow obstructed and then escaped the channel

from the earlier 2005 and 2007 flows, creating a new flow path towards Smoky Spring Pond. A hiking trail was obstructed, a cattle fence damaged, and a large fraction of Smoky Spring Pond was filled with muddy debris.

Rock-Fall and Avalanches

Large areas of the Ashley National Forest exhibit steep slopes, deep winter snowfall, and rock units susceptible to avalanches and rock-fall hazards. However, these areas are typically remote, and the hazards are well known, such that Forest Service infrastructure and visitors can generally avoid the most hazardous areas. Rock-fall hazards and snow avalanches are best mitigated by keeping valuable infrastructure and forest visitors away from steep or vertical cliff areas. A large snow avalanche occurred in the Rock Creek area of the Duchesne District in 2005, which blocked an important access road and splintered many trees.

Earthquakes and Volcanos

The Ashley National Forest is located in an area of the United States with no active volcanic activity. However, there is a moderate risk of infrastructure damage from local or regional earthquakes. Geologic maps show numerous bedrock faults scattered across the Ashley National Forest. Most of these faults are old and inactive, created or related to large-scale crustal movements that are no longer active. However, there are several faults or fault zones along the margins of the Uinta Mountains, and within the Uinta Basin, which are geologically active. These faults (or others) could have significant earthquakes from time to time. Two recent earthquakes occurred on May 25, 2016, near the Rock Creek area of the Duchesne District (USGS, 2017). Although these earthquakes occurred in a remote area of the Forest, and were relatively small (magnitude 4.0 and 2.7), they demonstrate the ongoing risk from earthquake hazards.

In addition to local geologic faults, the western portions of the Ashley National Forest are located only about 30 miles from the well-known and geologically active Wasatch Fault Zone. Because of this, visitors and infrastructure in the western portions of the Ashley National Forest would also be at risk from large earthquakes on the Wasatch Fault Zone. Damage from large earthquakes could occur on the Ashley National Forest, even when the earthquakes themselves occur along the Wasatch Front. Such hazards cannot be stopped or avoided, but infrastructure can be designed with such hazards in mind, to avoid or minimize any actual harm.

Although the risk of active volcanic activity within the Ashley National Forest is very low, the Yellowstone Hot Spot and associated volcanic system lies about 200 miles to the north. Catastrophic volcanic events associated with the Yellowstone Hot Spot could easily send ash more than 200 miles, and could impact operations and ecosystems within the Ashley National Forest. Odds of such an event occurring within the next few years is very low, and impacts from such an event would reach far beyond the boundaries of the Ashley National Forest.

Karst Collapse and Flooding

Certain kinds of bedrock are susceptible to the creation of natural caves and underground drainage systems. Areas with such rocks, where caves and underground drainage systems have developed, are often called "karst areas" by geologist and other scientists. The Ashley National Forest includes several karst areas, and large areas of the forest are underlain by karst-susceptible rock units. Within the Ashley National Forest, the susceptible rock units include the Madison Limestone, Round Valley Limestone, portions of the Humbug Formation, and gypsum beds within the Carmel Formation. A few large karst sinkholes and karst collapse features are known to exist on the Ashley National Forest. However, these karst features are typically associated with known caves and karst systems, and are typically located in

rugged and remote areas with little infrastructure. The rugged topography also results in the active drainage channels typically being located at considerable depth, well below surface developments. As such, collapse of karst features is not a significant risk to human health or most infrastructure on the Ashley National Forest. However, water storage facilities and other large or critical infrastructures should not be developed on or adjacent to suspected karst areas or karst-susceptible bedrock without first considering the potential hazards present. Areas of the Ashley National Forest underlain by bedrock units susceptible to karst development are shown on Plates 2 through 5.

Several natural caves on the Ashley National Forest are prone to flash flooding, particularly during spring runoff (May and June), or when water is released from upstream reservoirs. Flooding of cave systems can be extremely hazardous or fatal to unwary visitors because it can occur quickly, and because escape routes and cave entrances are often also flooded. Caves prone to flash flooding should not be visited in seasons when flash-flooding is likely.

Radon, Methane, and Hydrogen Sulfide

Radon, hydrogen sulfide, and methane are all potentially hazardous gasses, which might pose risks at certain places within the Ashley National Forest. Radon is a heavy radioactive gas created by decay of naturally occurring radioactive elements within granites, clay deposits, and other types of rocks and soil. Being heavier than air, radon is a hazard to human health where it seeps out of the ground and concentrates poorly ventilated underground spaces like basements. Large areas of the Ashley National Forest are underlain by clay-rich bedrock. Enclosed buildings and structures should be ventilated, to prevent accumulation of radon.

Large amounts of methane occur in bedrock within the South Unit of the Duchesne District, where it is economically produced as natural gas. Although abundant, the methane occurs several thousand feet below the surface, and does not typically leak to the surface. Leaks or fires related to methane production facilities pose a potential industrial hazard. Naturally occurring methane gas often also contains variable amounts of hydrogen sulfide, which is an extremely toxic gas. Hydrogen sulfide can pose an industrial hazard for methane (natural gas) production and transportation facilities. Away from industrial production facilities, the naturally occurring methane and hydrogen sulfide are probably not significant geologic hazards.

Trends and Drivers for Geologic Hazards

Geologic hazards within the Ashley National Forest exist largely because of pre-existing geologic conditions, and are generally independent of Forest Service plans, budgets, or actions. Many geologic hazards exist now, and most of them will continue to exist for the foreseeable future. As local populations increase, and Forest visitation and infrastructure increases, more people and structures are present on the Forest to be impacted but the existing hazards. However, the risk of actual damage or injury from many geologic hazards can be greatly minimized by careful planning, hazard documentation, public education, and engineering. Where possible, areas with known geologic hazards should be identified, evaluated, and documented. With greater awareness and education efforts, future visitors and future infrastructure on the Forest can be located away from known high-risk areas. Future forest infrastructure can also be designed to account for known hazards (such as earthquakes) than cannot be avoided.

Figure 7. Fossil plant leaf from the Ashley National Forest

Geologic Resources

The Ashley National Forest includes a wide variety of geologic resources. These resources include paleontological (fossil) resources, caves and karst resources, and areas with rock layers or geologic features having scenic, educational, or scientific values. Significant fossils and cave resources are protected by federal laws. These laws include the 1988 Federal Cave Resources Protection Act, the Paleontological Resources Preservation Act (part of 2009 Public Law 111-11), and others. Forest Service regulations for proper recognition, management, and protection of these resources can be found at 36 CFR 290 and 36 CFR 291. Other types of geologic resources, such as management of karst areas, are left largely to Forest-level management and discretion. The 1986 Ashley National Forest Plan contains little or no guidance for management of geologic resources.

Paleontological (Fossil) Resources

The Ashley National Forest contains a wide variety of fossils, representing many different ancient creatures, many fossils types, and a wide range of geologic ages. Some of these fossils have considerable scientific or educational value. There are numerous Paleozoic (pre-dinosaur age) aquatic invertebrates (shells, corals, bryozoans, crinoids, etc.) on the Forest. There are also rare Mesozoic (dinosaur age) bones, tracks, and trace fossils, as well as shark teeth and fish scales. There are also Tertiary (post-dinosaur age) fish, mammal, crocodile, turtle, and a diverse range of well-preserved plant fossils. There are also poorly documented Ice Age to recent cave deposits containing undescribed bones, woody plant materials, and other materials of potential scientific value. Many of these fossil resources and associated locations are protected by law. Site locations should not generally be advertised or disclosed by the Forest Service, except to qualified scientific researchers, and for valid educational or research purposes. Known sites should be documented, and managed or periodically inspected, to protect them from inadvertent damage or illegal collection.

Caves and Cave Resources

The Ashley National Forest includes a variety of natural caves and cave resources. On federal lands, natural caves and their resources are specifically protected by law. The names, locations, and resources of significant caves are protected and kept confidential, to protect their unique resources from deliberate or inadvertent harm, in accordance with agency regulations and the 1988 Federal Cave Resources Protection Act. Disclosing information for well-known caves is sometimes acceptable, since the caves are already well-known, are being properly managed, or have already been irreversibly damaged. The caves themselves will be discussed first, followed by a discussion of various resources associated with some of those caves.

The Ashley National Forest contains numerous natural caves, of which 41 have been documented and designated as Significant Federal Caves. Of the known caves on the Ashley National Forest, only a few are large or well known. The largest caves are well known to local communities, and are periodically visited by the public. Whiterocks Cave is closed year-round, to protect a variety of sensitive resources, but the forest occasionally provides guided tours. Sheep Creek Cave is closed during winter to protect hibernating bats, but is open during summer. The other well-known caves are not closed or gated and remain open year-round.

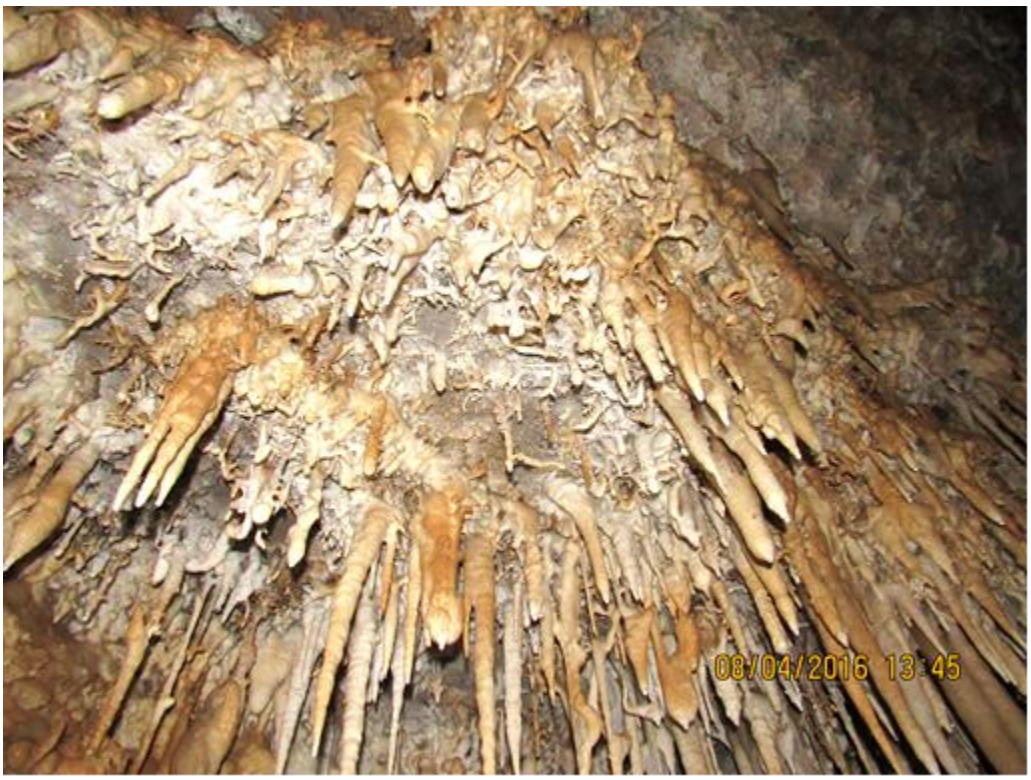


Figure 8. Cave resources within the Ashley National Forest

Several caves on the forest are prone to rapid and potentially lethal flash-flooding during spring and early summer. These include Big Brush Creek Cave, Little Brush Creek Cave, Pole Creek Cave, and a few others. Visitors to such caves should be careful to observe the weather and local stream and snow-melt conditions prior to entering. Little Brush Creek Cave can also flood unexpectedly at other times of year, when water is released from East Park Reservoir.

Cave-related resources known to occur within the Ashley National Forest include scenic and non-scenic cave formations, cave sediments and deposits holding scientific information, critical habitat for cave-

dependent animals, and karst-dependent surface springs and ecosystems. Most caves on the Forest are not well decorated with scenic formation, but Whiterocks Cave contains a wide variety of abundant and scenic cave formations. Big Brush Creek Cave and Little Brush Creek Cave have very few formations per se, but have scenic seasonal ice formations, impressive logjams, and large areas where the bedrock has been sculpted into interesting patterns by floodwater.

Most caves contain sediments or mineral or ice deposits with potential scientific value. Caves are very good environments for recording and preserving recent geologic history, which in other environments are often quickly destroyed. Some caves preserve useful scientific data from the surrounding surface, including ancient plant and animal communities, fire history, volcanic events, atmospheric dust and pollen, human history, or climate conditions and fluctuations in the past. Many caves contain a few old bones of uncertain age or scientific value, but some caves on the forest contain older bones and fossils of scientific value. When first explored, Whiterocks Cave was found to contain a complete human skeleton of unknown age. Several caves on the forest semi-permanent or persistent ice deposits, possibly hundreds or thousands of years old.

Although not well documented, caves on the Ashley National Forest provide important habitat for many animal species. These include at least 7 species of bats, various rodents, and many types of invertebrates (some of which are blind or otherwise cave-adapted).

Several of the large and important springs in the local area drain from or associated with caves and karst drainage systems on the Ashley National Forest. Impacts or pollution at some caves or karst systems on the forest can travel to important surface springs very quickly, and can greatly affect both local wildlife and public drinking water systems. This is true, even when the springs are located in different stream drainages, or are many miles from the caves or karst areas in question.

Karst Areas

The Ashley National Forest includes several areas where the local geology tends to create natural caves, sinkholes, disappearing streams, large springs, and underground drainage systems. Geologists refer to such areas (the surface as well as the caves and drainage systems) as being “karst" or "karst areas”. Most karst areas are associated with rock layers of limestone, dolomite, or gypsum, because underground drainage systems can form more quickly in such rocks.

Little formal guidance is available for management of karst resources. Many people recognize caves as interesting and valuable resources, but few are aware of the importance of the related karst areas and subsurface drainage systems. Karst areas are often subtle, and the drainage systems and caves are often deep underground and difficult to observe. Management of cave-related resources tends to focus on individual known caves, even though they represent only a small fraction of the actual caves and related resources that certainly exist.

The Ashley National Forest includes several karst areas, some of which are large and well developed, have impressive features, or are related to popular caves and important surface springs. Some of the larger karst areas on the Forest occur in the Brush Creek, Dry Fork, Sheep Creek, and Blind Stream areas. Some karst areas have obvious or documented caves, while others do not. However, caves and cave resources are certainly present at depth in most karst areas, to create the surface karst features and subsurface water transport observed. Proper management and protection of cave and karst resources and related groundwater should apply to known karst areas (critical cave habitat), even where significant caves have not yet been discovered. Otherwise, many important caves or resources could be inadvertently damaged or destroyed, simply because a cave entrance has not been located. Areas of the Ashley National Forest

with karst-susceptible bedrock units, where cave and karst resources are most likely to occur, are shown on Plates 2 through 5.

Some karst areas and systems present significant hazards, including flash flooding, rapid water or soil piping, rapid contaminant transport, and collapse of large subsurface voids.

Special Geologic Areas

The Ashley National Forest has a Special Management Area designated specifically for geology, called the Sheep Creek Geologic Area. There is also a National Scenic Byway with a geology-based theme, called Drive through the Ages (part of the Flaming Gorge – Uintas Scenic Byway). The Sheep Creek Geologic Area was designated as a special management area to highlight some of the interesting geologic features in that area. These features include several interesting rock layers, large scenic cliffs, a geologic fault, a large karst spring, and a large natural cave open in summer for recreation and exploration. Drive through the Ages includes a series of sign-posts along Highway 191 as it passes over the Uinta Mountains. Each sign identifies a different rock layer the Highway is passing over, and briefly notes something about that layer (environment responsible for creating it, or types of fossils found). The rock layers span more than 600 million years of geologic history, and represent a wide variety of past geologic environments. Drive through the Ages is co-managed by the Ashley National Forest, the Utah State Parks, Utah Department of Transportation, and others.

Trends and Drivers for Geologic Resources

Geologic resources within the Ashley National Forest exist largely because of pre-existing conditions, and tend to be created only slowly, by natural processes over long periods of time. These resources are similarly destroyed by natural processes, usually over long period of time, and are considered non-renewable resources. Many geologic resources exist on the Ashley National Forest right now, and most of them will continue to exist for the foreseeable future. However, most of the fossils and cave resources on the Forest remain hidden deep underground and have not been discovered or documented. Discovery of new geologic resources is based either on accidental finds by the general public, or by the deliberate effort of Forest Service staff, geologic experts, and resource enthusiasts. Many fossils and caves are discovered by accident, during management actions for other resources, where they can be overlooked and inadvertently destroyed. Since geologic resources are created only slowly, but can be destroyed rapidly by public or management actions, the trend is towards destruction of existing geologic resources. The driver for that destruction is often lack of careful management and general awareness of the resources.

Management of geologic resources tends to follow dedicated staff with interest and expertize, as well as interest from non-agency scientific researchers and resource enthusiasts. Management of geologic resources also fluctuates when dedicated minerals and geology staff and budgets are diverted to or from more urgent (and less discretionary) locatable, leasable, and salable minerals activities and projects.

The destruction of existing geologic resources can be minimized by better understanding of the resources, and where they are likely to occur, coupled with appropriate mitigations and restrictions on Forest management projects, sites, and recreational activities. To better understand the resources we have, careful identification and documentation of known resources is needed, along with a deliberate search for existing but unknown resources. Public education and awareness of geologic resources is also helpful. However, releasing specific information for some resources can lead to increased destruction of those resources, due to increased public visitation and inadvertent or illegal damage or collecting.

Summary

The Ashley National Forest contains a wide variety of energy, mineral, and geologic resources, as well as geologic hazards. Each of these resources or hazards are different, and have different issues, drivers, and applicable laws and regulations to be followed and considered.

Demand and development for energy and mineral resources is largely related to fluctuations in industry demand and global market pricing for those resources. Management of those resources on the Ashley National Forest is therefore primarily dependent on, and responsive to, public and industry interests, rather than long-range Forest or agency planning or budgets. Management of energy and mineral resources also requires close coordination with public agencies and industry representatives, because responsibility for management overlaps with other agencies, and because proposals and funding for development come from industry. Management of energy or mineral resources requires consideration of numerous applicable laws, jurisdiction of other Federal or State agencies, and valid existing rights, including non-Federal mineral rights. Management of mineral and energy resources on the Ashley National Forest is already governed by a large volume of existing laws, agency regulations, and case law, and is not particularly discretionary at the local forest or forest planning level. Properly following existing laws and regulations can prevent undue or unacceptable impacts from energy, and locatable and leasable minerals development.

Geologic resources and hazards are naturally occurring, and result from pre-existing geologic history, topography, rock layers, climates, and tectonic and volcanic activities. Proper management of geologic resources and hazards requires identification and documentation of the existing resources and hazards.

Although geologic hazards cannot be eliminated, the risk or severity of damage and injury can often be greatly minimized by hazard identification and documentation, public education, and appropriate mitigations and engineering. Future visitors and future infrastructure on the Forest can be located or focused away from known high-risk areas. Future forest infrastructure can also be designed to account for known hazards than cannot be otherwise avoided.

Geologic resources should be identified and documented, to make them available for appropriate scientific study, and so they can be better protected from ongoing natural and human destruction. While some of these resources are protected by laws and agency regulations, considerable forest-level discretion is allowed in management of specific sites and resources. Forest management actions and recreational activities should include appropriate mitigations and restrictions, to minimize inadvertent or deliberate destruction of important geologic resources.

Note: The following plates must printed on paper sized 11 by 17 inches.

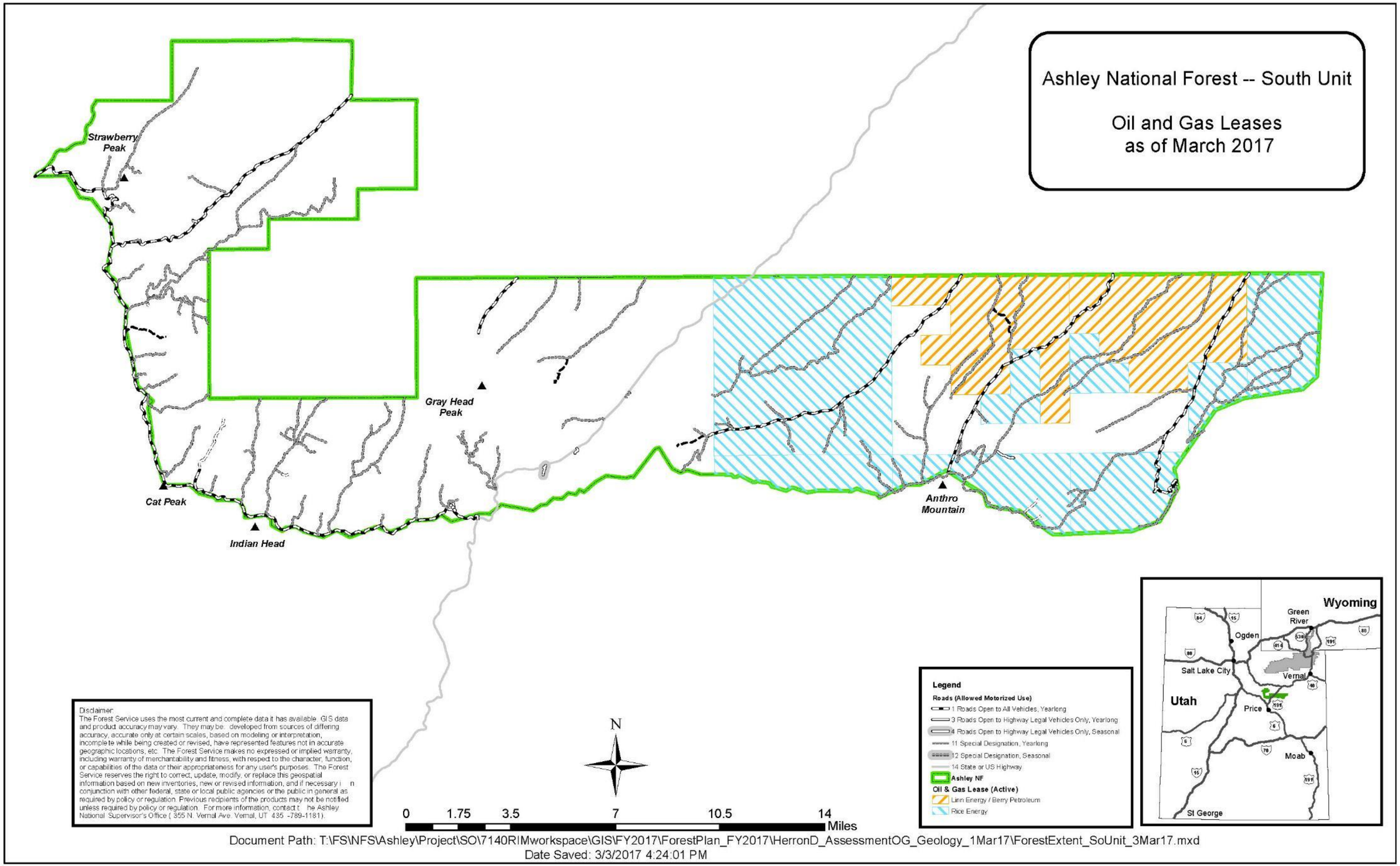
Plate 1: Federal Oil and Gas Leases on the South Unit of the Ashley National Forest

Plate 2: Geologic Hazard Areas - South Unit of Duchesne District

Plate 3: Geologic Hazard Areas - North Unit of Duchesne District

Plate 4: Geologic Hazard Areas - Vernal District

Plate 5: Geologic Hazard Areas – Flaming Gorge District (Utah portion only)



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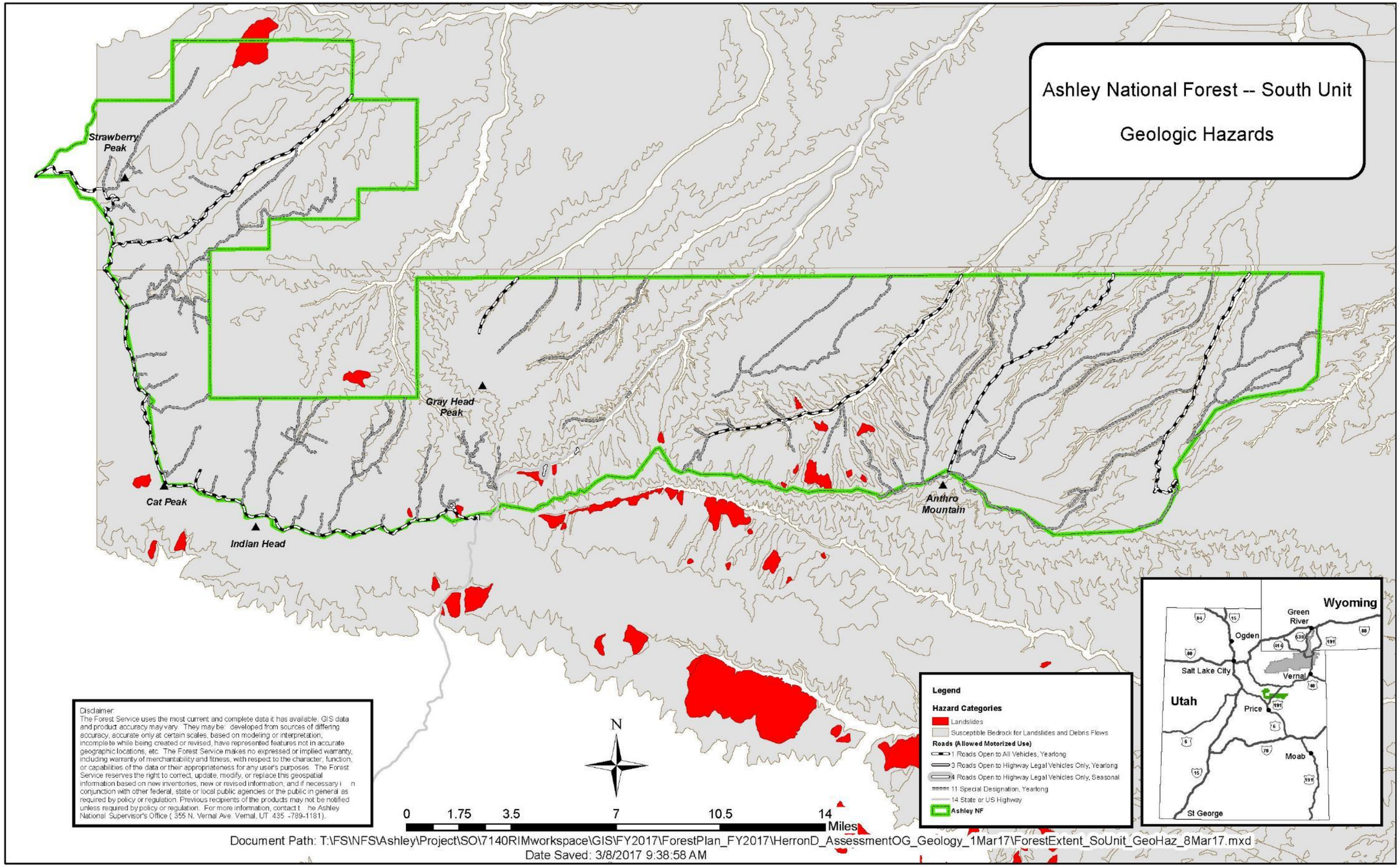
Ashley National Forest -- South Unit
Geologic Hazards
Strawberry Peak
Gray Head Peak
Cat Peak
Indian Head
Anthro Mountain
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N
0 1.75 3.5 7 10.5 14
Miles
Legend
Hazard Categories
Landslides
Susceptible Bedrock for Landslides and Debris Flows
Roads (Allowed Motorized Use)
1 Roads Open to All Vehicles, Yearlong
3 Roads Open to Highway Legal Vehicles Only, Yearlong
4 Roads Open to Highway Legal Vehicles Only, Seasonal
11 Special Designation, Yearlong
14 State or US Highway
Ashley NF
Wyoming
Green River
Ogden
Salt Lake City
Vernal
Utah
Price
Moab
St George
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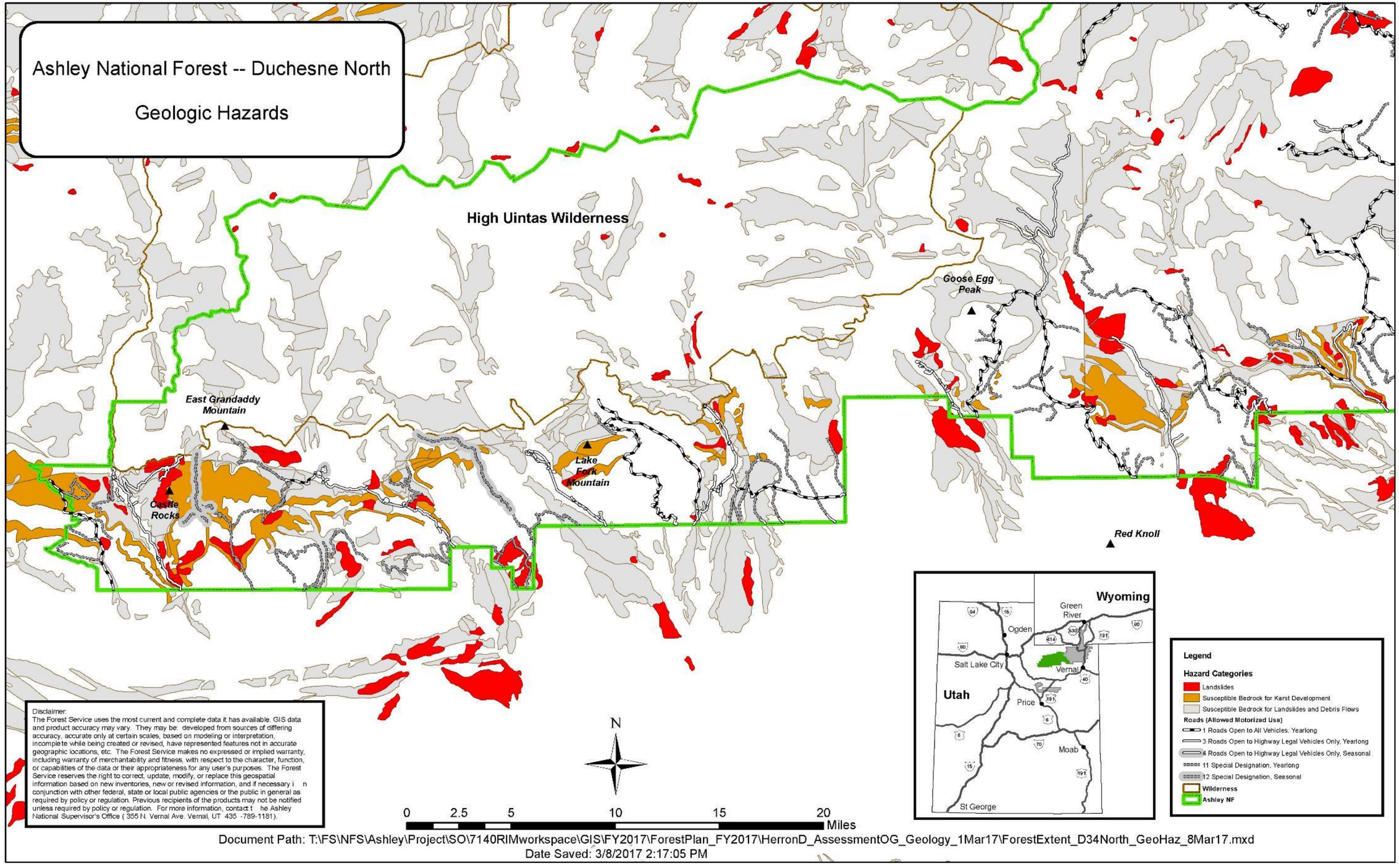

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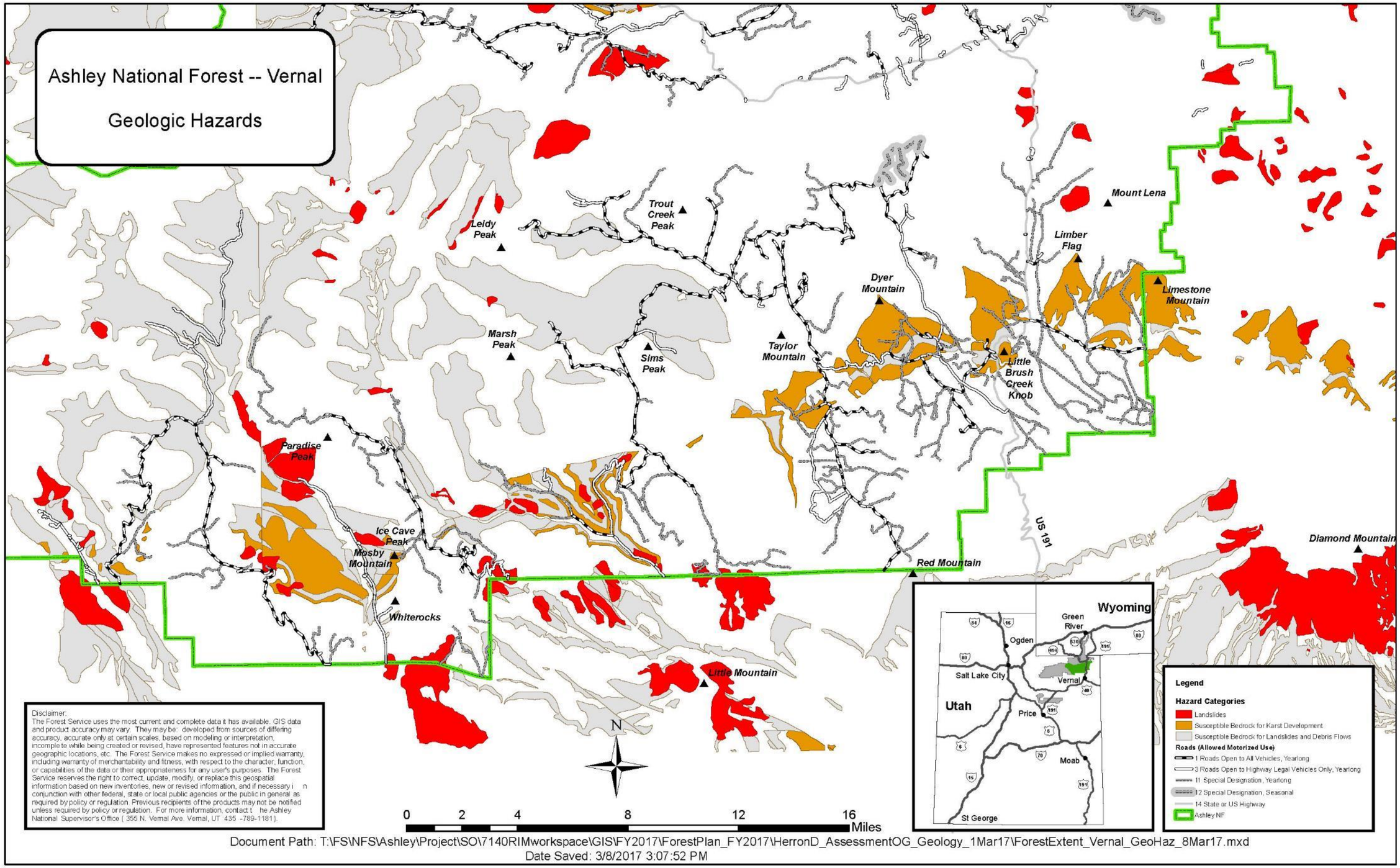
Ashley National Forest -- Vernal
Geologic Hazards
Trout Creek Peak
Leidy Peak
Marsh Peak
Sims Peak
Taylor Mountain
Dyer Mountain
Limber Flag
Mount Lena
Limestone Mountain
Little Brush Creek Knob
Paradise Peak
Ice Cave Peak
Mosby Mountain
Whiterocks
Red Mountain
US 191
Diamond Mountain
Little Mountain
N
0 2 4 8 12 16
Miles
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Wyoming
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11 Special Designation, Yearlong
12 Special Designation, Seasonal
14 State or US Highway
Ashley NF
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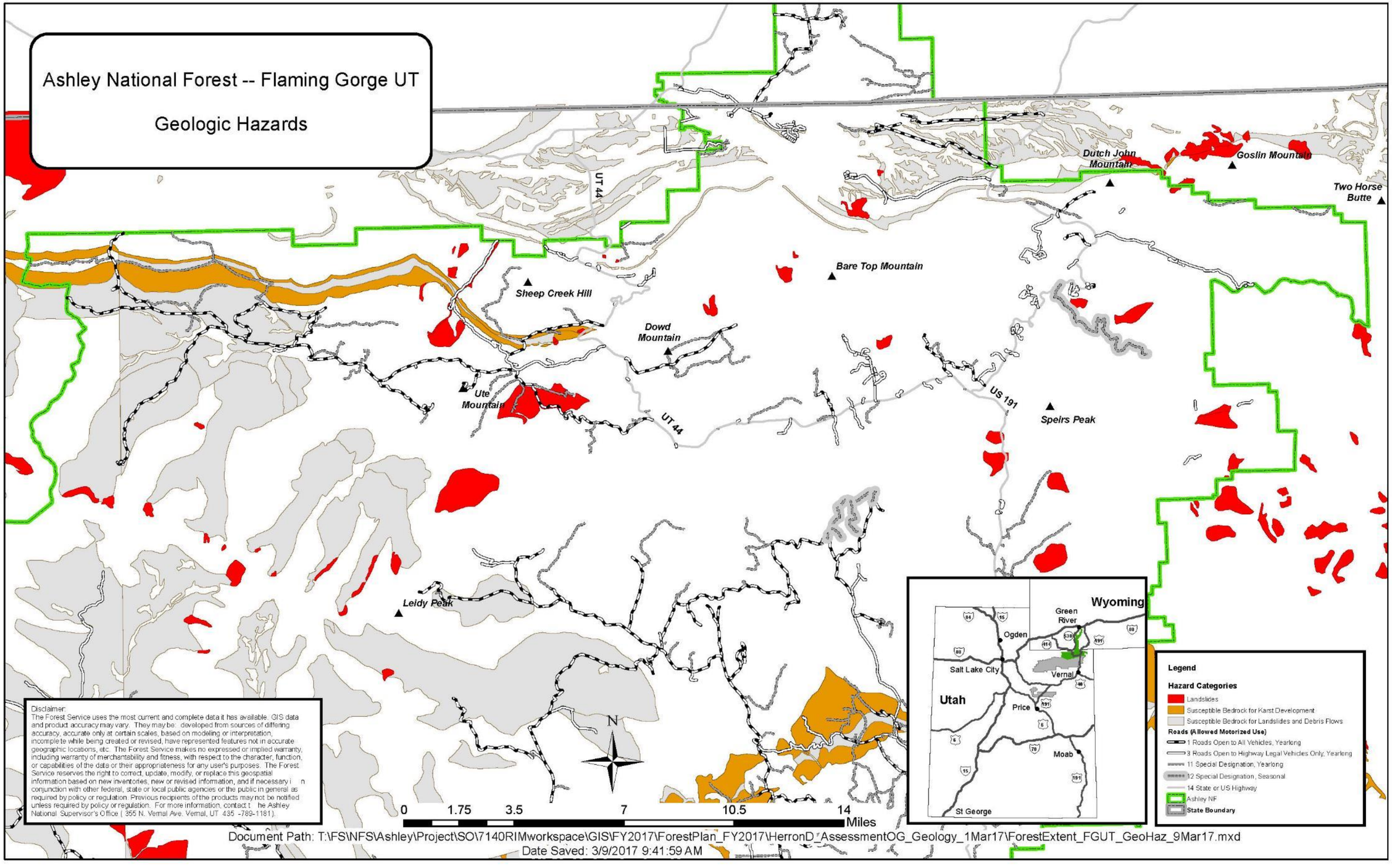
Ashley National Forest -- Flaming Gorge UT
Geologic Hazards
UT 44
Dutch John Mountain
Goslin Mountain
Two Horse Butte
Bare Top Mountain
Sheep Creek Hill
Dowd Mountain
Ute Mountain
UT 44
US 191
Speirs Peak
Leidy Peak
N
0 1.75 3.5 7 10.5 14
Miles
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Ashley NF
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